C 4 2 20 ... 50

PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: HANS RICHARD DOLF and WILLIAM EARL MARCEAU

1,028,481

1,028,481

Date of Application and filing Complete Specification April 14, 1964.

No. 15466/64.

Complete Specification Published May 4, 1966.

Index at acceptance:—F4 B(7V1, C10A); C1 M(11A2, 11S, D8)

Int. Cl.:—C 03 b//C 03 c

COMPLETE SPECIFICATION

Improvements in or relating to a Method of Melting Glass and Apparatus therefor

We, SELAS CORPORATION OF AMERICA, a corporation organised under the laws of the Commonwealth of Pennsylvania, one of the United States of America, of Dresher, Commonwealth of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the melting of glass or similar materials, and more particularly to the use of submerged combustion for this purpose by means of which large quantities of glass can be melted in a relatively small area.

Ordinarily glass batch and cullet are placed in a glass furnace and melted by heat developed by firing across the top of the glass. As the glass is melted it flows from a melting zone to a fining zone, and from there to the point of discharge. These furnaces are large and relatively inefficient.

In glass tanks, and particularly large tanks adapted to produce many tons of glass per day, a large melting and refining area is required to produce glass that is free from seeds and bubbles. Ordinarily about one-third of the area of a tank is devoted to the melting of the batch and cullet that is used as raw material, while the remainder of the area is used for fining the glass before it is drawn off for use. If some way can be provided for improving the melting technique for glass, the furnace size can be reduced approximately one-third while still leaving the same area for fining of the glass.

In practicing the invention, a burner having an air cooled casing is inserted in the furnace wall. This burner has in it provisions for mixing fuel gas and air, burning them, and discharging the products of combustion at high temperature and velocity into the glass. The hot gases agitate the glass and impart a high percentage of their heat thereto, thus melting the glass rapidly. The feed for such a furnace can be either cullet or batch, or a mixture of the two. The raw material is fed to the melter near or under the surface of the glass in a location where it will be drawn into the glass and circulated therewith by currents resulting from the hot gases, thereby to be rapidly melted. After the glass is melted it flows from the melting zone to a separate fining zone and from there to a point of use.

In further practicing the invention there are provided a plurality of high efficiency melting units that supply molten glass to a large refining tank. These melting units are fired by submerged combustion to melt and thoroughly mix the ingredients of the glass so that, when it is delivered to the refining tank, only the fining step must take place in a conventional manner before the glass is delivered to the point of use.

There is proposed, in accordance with the invention, a method of melting glass or like material in a suitable melting tank which comprises introducing hot products of combustion above the melting point of the material into a molten mass of the material at a plurality of points beneath the surface of the material, creating vertical upwardly and downwardly circulating currents of the material by the hot products of combustion adjacent to the points at which the combustion products are introduced thereby to mix the material uniformly, withdrawing melted material continuously from one location of the tank and introducing material to be melted continuously into the tank at a loca-

[Pri----

BEST AVAILABLE COPY

tion therein where the currents are moving downwardly.

The present invention additionally provides apparatus for treating glass and the like including a melting tank having a floor and side walls, the tank also having inlet and outlet means for the introduction of material to be melted and the removal of molten material, said floor being provided with a plurality of spaced openings, a burner received in each opening with an end of each burner projecting above the level of the floor but below the level of the material in the tank, each burner including a combustion chamber with a discharge opening, the opening terminating in the portion of the burner projecting above the floor, means to supply gas and air to the burner to be burned in the combustion chamber, the products of combustion resulting therefrom passing through the opening into the melting tank.

In order that the invention may be more clearly understood and readily carried into effect, the same will now be described more fully with reference to the accompanying drawings, in which:—

Fig. 1 is a section through apparatus in which glass is melted and refined;

Fig. 2 is a view taken on line 2—2 of Fig. 1;

Fig. 3 is a section through the burner showing it mounted in the furnace floor;

Fig. 4 is a view, in section, of a glass refining tank and a plurality of melting tanks used therewith;

Fig. 5 is an enlarged view, in section, taken on line 5—5 of Fig. 4; and

Fig. 6 is a view similar to Fig. 5 showing a modified form of melting tank.

Referring to Fig. 1, there is shown the fining section of a glass furnace 1 through which the glass moves to a forehearth and a point of use. Liquid glass is supplied to this section over a weir 2 from a melting chamber or zone 3 in which the glass in the form of batch or cullet is melted. The melting is accomplished by burners 6 which are completely submerged under the liquid glass, and are mounted in the furnace by extending through openings provided for this purpose in the floor 4 of the furnace. Raw materials for making the glass are supplied through a spout 7, the lower end of which is located between a pair of the burners in a manner to be described more particularly below and at a level immediately above or slightly below the normal liquid level of the glass in the furnace. The raw material is supplied to this spout from a hopper 8 with normal control of the supply, and the products of combustion from the burners which rise through the glass are discharged from the chamber 3 through a flue 9.

An important feature of the invention is the construction of the burners 6 which permit them to be located in the floor of the melting zone and beneath the level of the glass. A section through one of these burners is shown in Fig. 3. Referring to that figure, it will be seen that the burner extends through an opening 11 in the floor with the end of the burner projecting a short distance into the chamber. This burner comprises a base casting 12 that is mounted on some suitable support so that the burner is properly located in opening 11. Attached to the casting is a double wall casing consisting of an outer wall 13 that is received snugly in the opening 11 and an inner wall 14. It will be noted that the upper end of this casing is constricted inwardly from its normal cylindrical shape so that there is a small space left between the upper end of the opening 11 and the outer surface of wall 13. The space between the walls 13 and 14 is divided into two annular passages by a partition 15 which is supported on a disc 16 formed as part of casting 12, and connected to the lower part of this casting by means of a column 17 forming a portion of the gas passage. Partition 15 fits snugly on the periphery of disc 16, and is sealed with respect to this disc by means of a seal 18. The upper end of the partition is accurately positioned between walls 13 and 14 by means of a plurality of radially extending fins 19 which extend inwardly from wall 13 and around the edge thereof. Inner wall 14 is lined with a refractory 21 to form a combustion chamber having a restricted discharge opening 23 at the end of the casing. Fuel and air are supplied to the combustion chamber through a part 24 which is attached to disc 16. This part includes an annular gas chamber 25 having discharge ports 26 that are directed inwardly toward a point at substantially the center of the chamber. This part also has a central air passage 27 through which air for combustion flows to be mixed with the gas coming through ports 26.

Ignition of the mixture in the combustion chamber is obtained by a spark which is discharged across electrodes in an ignition rod. This rod includes a sleeve 28 forming the outer electrode which receives and is insulated from a center electrode 29 in the form of a wire. The ignition rod is slidable from the full line position shown to the dotted line position through guides that include a seal 31 in the disc 16 and a stuffing box 32 in the rear end of casting 12. It is noted that the outer electrode flares as shown at 33 to direct the air flowing through passage 27 across the jets of gas flowing through passages 26.

An air port 34 is formed in the casting 12 with the air flowing into this port and the casting through the annular path between wall 13 and partition 15, around the end of the partition, and back between wall 14 and

BEST AVAILABLE COPY

the partition to the space above disc 16 which leads directly to air passage 27. The casting 12 is provided with a gas passage 35 extending through column 17 directly to the annulus 25.

In some cases it may be desirable to use a plurality of melting chambers with a single refining furnace or tank. Such an arrangement is shown in Figs. 4 and 5.

Referring to these Figs., there is shown a large refining furnace or tank 1 in which the melted glass is refined as it is flowing from the melting chambers toward an outlet for use in any desired glass using apparatus. This tank may be heated in a conventional manner by recuperators which include burners and which are shown diagrammatically on each side of the furnace at 41. Glass is supplied to the tank 1 through openings 42, corresponding to weir 2 of Fig. 1, formed in the upper part of side wall 43 from a plurality of the melting chambers 3.

Each of the melting chambers 3 is mounted, in this case, in an elevated position on supports 44. In this case each chamber 3 is provided with a discharge spout 45 having a glass resistant wear plate 46 on its upper surface. Each of the discharge spouts of the melting chambers is sized so that it will fit snugly within an opening 42 with the roof of the melting chamber aligned with the roof of the refining tank. These tanks are built so that the floor of the melting chamber is at an elevation above the level of the floor of the refining tank, so that the depth of the glass in the melting chamber is not as great as the depth of the glass in the refining tank. While these chambers are shown as being on stationary supports 44, it is possible to mount them on rollers and tracks so that they can be moved from the position shown with relation to the refining tank away from the refining tank, if necessary. When a melting chamber is moved away from the refining tank, the opening 42 will be closed by a refractory door.

The arrangement shown in Fig. 6 is similar to that of Fig. 5, except that the roof of the melting chamber in this case is provided with an exhaust stack 47. In this case the glass making material is charged through the exhaust stack into the melting furnace, and is melted therein as was the batch supplied through spout 7 in Fig. 5.

The melting tanks are of such a size that the molten glass is from 18 to 24 inches in depth. Such a depth has been found to require only reasonable pressures for the air and gas supplies to the burners for efficient melting. Liquid glass flows continuously from discharge spouts 14 into fining tank 1 where the glass can have a depth of several feet. Tank 1 is heated in a conventional manner, as noted above, by burners and recuperators, with the burners firing across the tank above the glass. In this manner the glass is maintained at the proper temperature and viscosity for refining as it flows through the tank.

The number of burners in each of the melting chambers will depend upon the capacity of the tank, and the number of melting chambers used for each refining tank will depend upon the capacity of the latter. The refining tank will have a capacity substantially equal to the capacities of all of the melting chambers. Ordinarily, however, the capacity of the melting chambers used with each refining tank will be somewhat more than is necessary for the capacity of the refining tank. In this way the melting chambers can normally be fired slightly under capacity without materially decreasing their efficiency, but can be fired at or above capacity when one of them must be shut down for service or repairs. The large refining tank, where the wear is much less severe, can thus be run continuously. By removing the melting function from the refining tank, the length of a campaign can be materially increased.

With the construction shown in Fig. 6, some or all of the products of combustion rising through the glass will be discharged through stack 47, thus preheating the material being supplied to the tank. This arrangement increases the efficiency of the melting operation, but should only be used if the raw materials are cullet or pelletized batch. Loose raw material should be supplied, as shown in Fig. 1, closely adjacent to or under the glass surface.

In operating the system gas and air are supplied to the burners in preselected proportions, which are slightly lean, for the gas being used by any conventional ratio controller. With the igniting rod in its dotted line position of Fig. 3, a spark is jumped across the electrodes to ignite the mixture and the rod is withdrawn to its normal operating position. In this position the flaring end 33 of the rod directs the air across the jets of fuel issuing from ports 26 so that good mixing takes place. Burning of the fuel is completed within the combustion chamber, heating the wall 22 thereof to incandescence, which helps to maintain combustion and increase the capacity of the burner. As the burner heats up the air will be preheated while at the same time cooling the metal parts sufficiently to insure a long life. Fins 19 extract enough heat from the end of the burner so that it is kept below a temperature at which the metal can be attacked by the molten glass.

The hot products of combustion issuing at high velocity from discharge port 23 are directed into melting chamber 3 to heat the chamber and the parts adjacent thereto. When the furnace has been brought up to temperature, raw material, preferably initially in

the form of cullet, is introduced through spout 7 and, as it begins to cover the burners, is melted by the gases issuing from them. The level of the glass can vary between wide limits and may be two or three feet above the burner discharge ports. Whatever the level, the pressure of the fuel and air supplies must be sufficient to overcome the head of glass.

As the products of combustion flow up through the glass, they disperse and weave around rather than form vertical openings directly to the surface. This action produces currents in the glass with the hottest portions, adjacent to the burners, rising and cooler portions, adjacent to the walls and between the burners, moving down, with a general current in the direction of weir 2. Thus, in addition to being melted, the glass is thoroughly mixed to a uniform mass. The feed of batch and cullet is introduced at a relatively cooler location, between burners, so that it is first drawn downwardly and mixed with the liquid glass as it begins to melt. Introduction of the raw material at a location where the current of the material is downward insures immediate mixing. If the raw material is granular it can be dropped on the surface of the molten mass from a point closely adjacent to the surface. If, however, the raw material is a powder or has powder in it, the raw material should be introduced into the molten mass below the surface, as shown in Fig. 1, so that the products of combustion will not blow the powder around the chamber and against the furnace walls. Since the burners are spaced from walls 5, the glass adjacent to the walls is cooler and more viscous than that at the center of the chamber. Therefore, there is less or slower flow of the glass along the wall.

The glass in contact with the shell of the burner is cooled sufficiently by heat transfer through the wall thereof to the combustion air to freeze. Thus, there is a thin layer of solid glass, as shown by line 36 in Fig. 3, in contact with the burner around opening 11. This serves the purpose of insulating and protecting the burner tips from wear as well as filling the space between the opening and burner to prevent leakage.

Movement of the gases up through the glass will have a tendency to produce bubbles. Since at this time the glass is hot and of low viscosity, the bubbles will readily rise to the surface and burst. Those which do not rise in chamber 3 will be carried with the glass in a thin layer over weir 2 or spout 46 where they will rise. Any bubbles remaining in the glass will flow into fining tank or chamber 1 where sufficient time is provided for the glass to be refined before being drawn off for use.

The gas and air will be supplied to the burner at a pressure of approximately one pound per square inch for each foot of glass depth in melting chamber 3 plus the pressure drop through the system. With an operation of this type complete combustion of the fuel takes place in combustion chamber 22, so that only hot products of combustion at a temperature of approximately 3000°F. are discharged into the glass to melt the glass and keep it at a suitable temperature and viscosity which will be about 2200° F., for soda lime glass, for example. The gases resulting from complete combustion of the fuel will not produce any discoloration of the glass. It is preferred to have the glass at no greater depth than is required to have the gases leave the glass at about the temperature of the glass, which makes very efficient heating and reduces the pressure requirements for the fuel and air.

The flow of combustion air through the burner casing is sufficient to keep this casing at a temperature between 950°F. and 1000°F., which is low enough for the burner to have an indefinite life. The temperature of the outer portion of the casing, which is above the level of the floor 4 and in the glass, is below the freezing point of glass so that the thin layer of solid glass, shown at 36, acts to protect and insulate the burner. It is noted that the combustion air, which serves to cool the burner tip, is preheated to about 400°F., thus increasing the efficiency of the apparatus. The number and size of burners required will, of course, depend upon the size of the melting chamber and its capacity. This can easily be calculated by one skilled in the art. A melting tank of this type can melt a ton of glass per day for each half square foot of area. It has been found that burners having a capacity range of from 250,000 to 750,000 BTU per hour are of a convenient size for a melter having a capacity of approximately 30 tons per day.

When it is desired to shut down the melting, gas to the burners is cut off while air continues to flow. In this way passages are retained throughout the glass so that the products of combustion can be discharged when the burners are relighted. Also, liquid glass will be prevented from flowing into the burners.

From the above it will be seen that we have developed an efficient method of melting glass and one in which the heat is released directly in the glass rather than indirectly, as is usual. The burner that is used in the apparatus is especially adapted for this purpose and contributes toward the efficient operation of the method.

It will also be seen that we have provided a novel arrangement of apparatus for melting large quantities of glass. The arrangement insures that all of the ingredients will be melted before they reach the fining tank, thus

contributing to its life. Also, since the refining tank is supplied with glass from a plurality of sources, each of which can be repaired or replaced independently of the other, the continued operation of the tank for its full life is insured.

The burners disclosed herein form the subject matter of our Application No. 25126/65 (Serial No. 1028482).

WHAT WE CLAIM IS:—

1. A method of melting glass or like material in a suitable melting tank which comprises introducing hot products of combustion above the melting point of the material into a molten mass of the material at a plurality of points beneath the surface of the material, creating vertical upwardly and downwardly circulating currents of the material by the hot products of combustion adjacent to the points at which the combustion products are introduced thereby to mix the material uniformly, withdrawing melted material continuously from one location of the tank and introducing material to be melted continuously into the tank at a location therein where the currents are moving downwardly.

2. The method according to claim 1, wherein the hot products of combustion are introduced from a plurality of spaced points through the bottom of the tank, and the material to be melted is introduced between adjacent points where the products of combustion are introduced and where the current of material is moving downwardly.

3. The method according to claim 1 or 2, wherein the material to be melted is introduced in the molten material close to or below the surface thereof.

4. The method according to any one of the preceding claims, wherein the glass immediately adjacent to the points where the products of combustion are introduced is maintained at a low enough temperature so that the glass is substantially solid and will flow very little, if at all.

5. The method according to any one of the preceding claims, wherein the material is melted in a plurality of melting tanks and is supplied from the plurality of melting tanks to a single refining tank.

6. A method of melting glass or like material in a suitable melting tank, substantially as hereinbefore described.

7. Apparatus for melting glass or like material according to the method of any one of claims 1 to 6, including a melting tank having a floor and side walls, the tank also having inlet and outlet means for the introduction of material to be melted and the removal of molten material, said floor being provided with a plurality of spaced openings, a burner received in each opening with an end of each burner projecting above the level of the floor, each burner including a combustion chamber with a discharge opening, the opening terminating in the portion of the burner projecting above the floor but below the level of the material in the tank, means to supply gas and air to the burner to be burned in the combustion chamber, the products of combustion resulting therefrom passing through the opening into the melting tank.

8. Apparatus for melting glass or like material according to the method of any one of claims 1 to 6, including structure forming a glass refining tank having a top and a floor at a given level below the top and a side, the refining tank being adapted to contain molten glass to substantially a predetermined level, means to supply heat to the refining tank above the predetermined level, structure forming a plurality of melting tanks each having a top, a floor and a discharge spout projecting substantially horizontally therefrom, the discharge spouts extending through the side of the refining tank at a level above the level of the glass therein, the top of the melting tanks being aligned with the top of the refining tank and the bottoms of the melting tanks being above the level of the floor of the refining tank, burner means extending through the floors of the melting tanks into glass contained therein to supply heat to melt the glass, and means to supply glass making material to the melting tanks, the glass melted therein flowing over the discharge spouts into the refining tank.

9. Apparatus according to claim 7 or 8, wherein each burner is provided around its surface and discharge end with a passage through which cooling fluid is to be circulated to cool the portion of the floor surrounding the burners and the material in the melting tank or tanks engaging the discharge ends, and means through which a cooling fluid is circulated through the passage.

10. Apparatus according to any one of claims 7 to 9, including means to supply material to be melted to the melting tank or tanks between a pair of the burners and adjacent to or below the level of the melted material in the melting tank or tanks.

11. Apparatus for treating glass and the like, having its parts constructed and arranged substantially as hereinbefore described with reference to Figs. 1 to 3 or to Figs. 4 and 5 or to either of these sets of Figs. as modified by Fig. 6 of the accompanying drawings.

HASELTINE, LAKE & CO.,
Chartered Patent Agents,
28, Southampton Buildings, Chancery Lane,
London, W.C.2,
Agents for the Applicants.

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1966.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

1028481 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

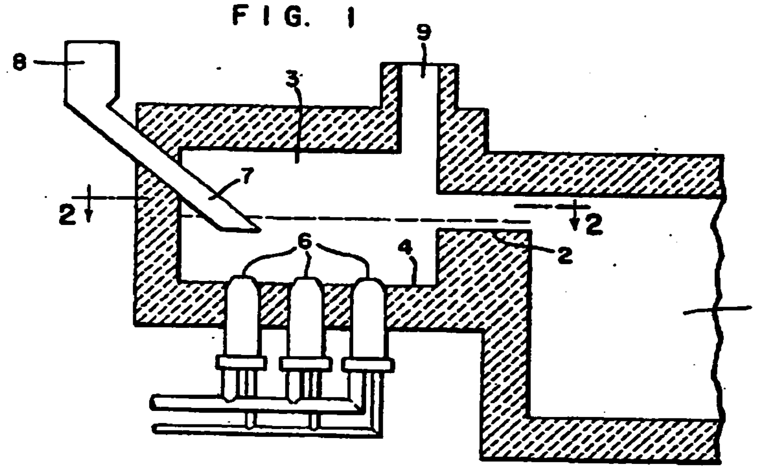
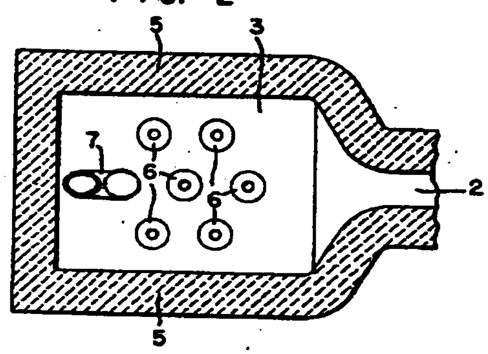


FIG. 2



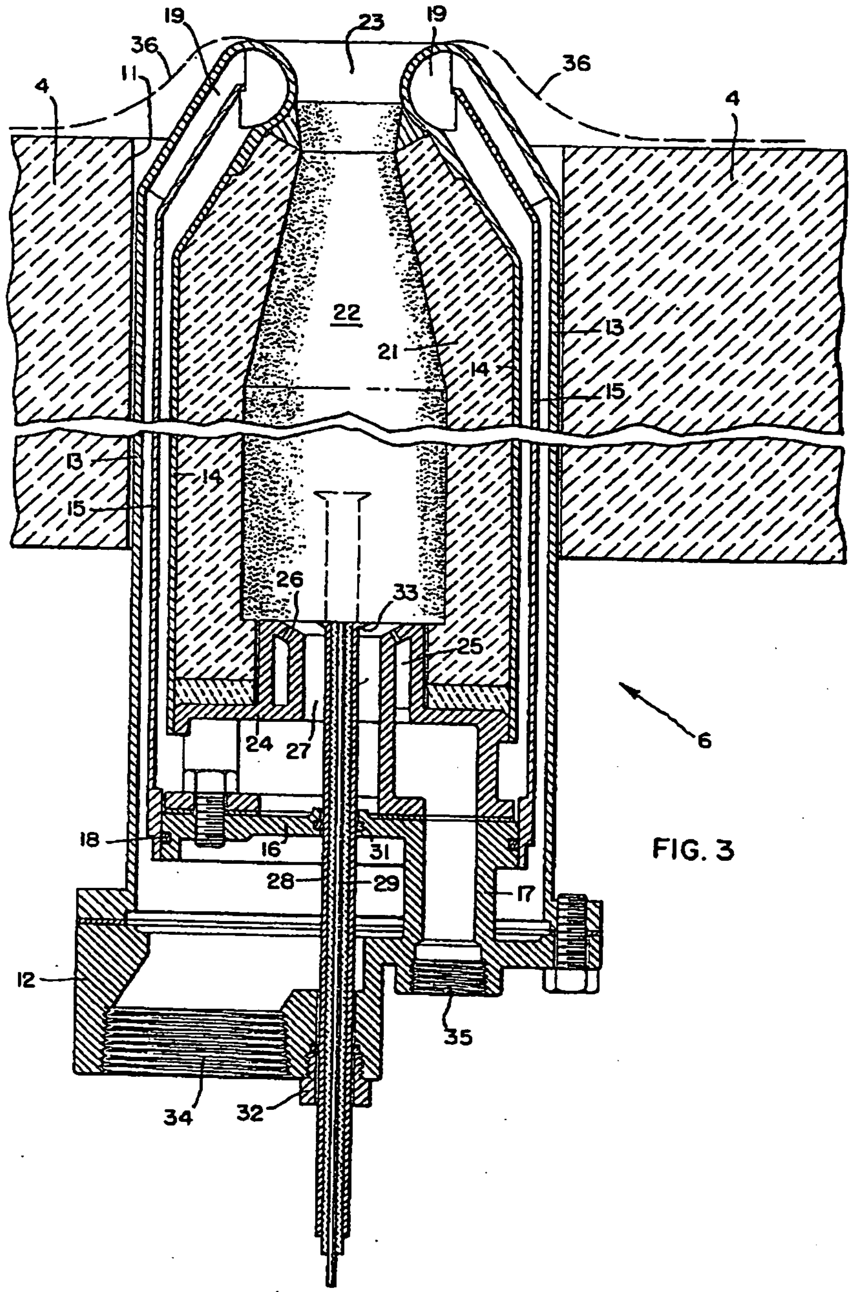

19
23
19
36
36
11
4
4
22
21
13
14
15
13
14
15
26
33
25
24
27
6
18
16
31
28
29
17
12
35
34
32

FIG. 3

47

3-

44

1028481 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 2 & 3

FIG. 4

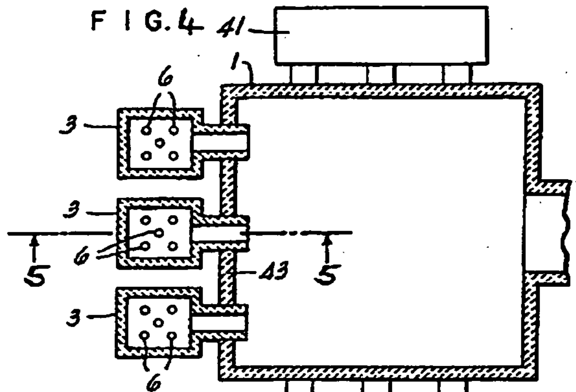


FIG. 5

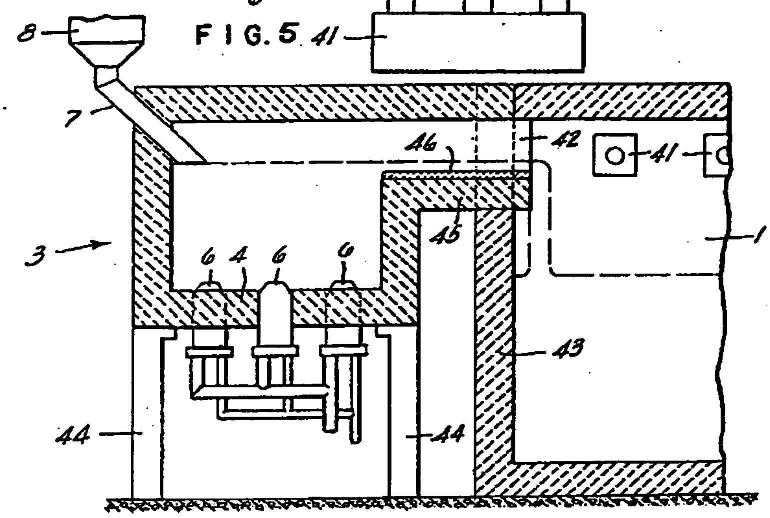
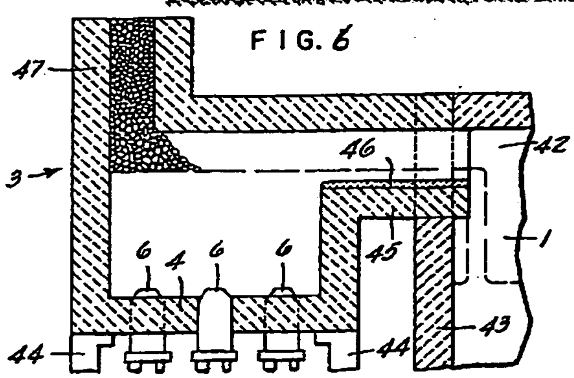
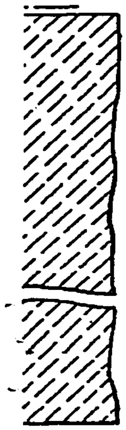


FIG. 6





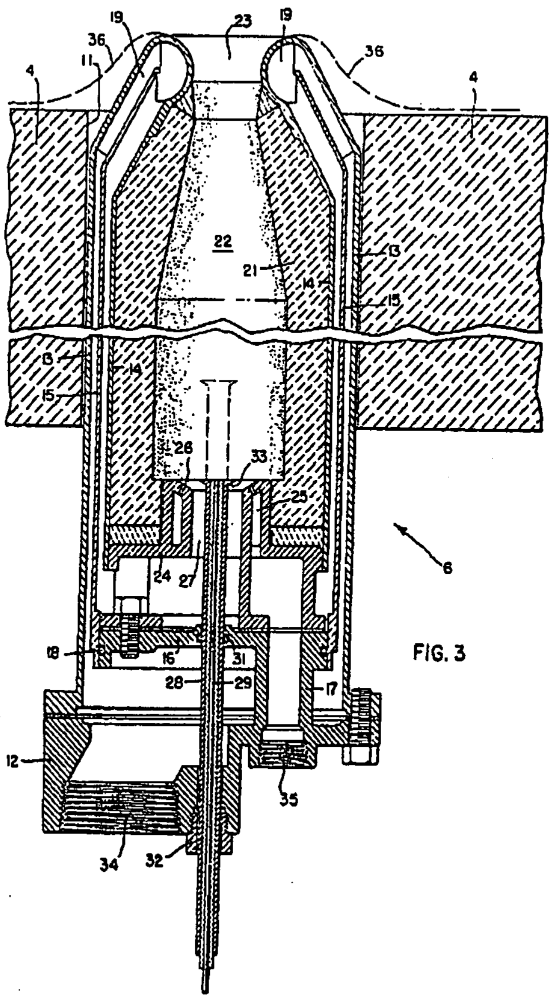
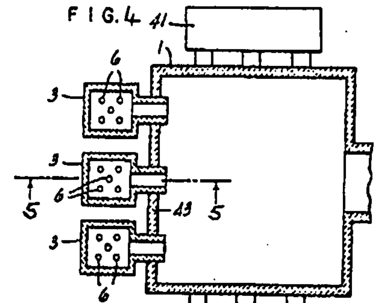
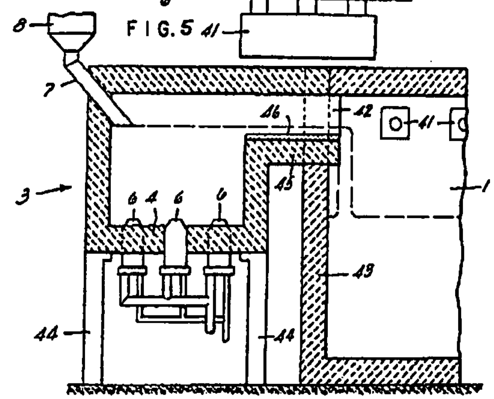


FIG. 3

F I G. 4



F I G. 5



F I G. 6